THE HEREDITY OF EYE COLOR AND HAIR COLOR IN MAN.

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Since the present study was begun several papers have appeared dealing with the subject matter of our investigations. Much of our data corroborates the conclusions expressed in these papers. In some cases the facts seemed to warrant some differences of opinion in regard to certain theoretical matters, and it was therefore deemed advisable to present the data obtained and the conclusions that appeared to be deducible therefrom.

The data were collected by sending out printed forms with headings under which to designate the eye color and hair color of each parent, grandparent and child and the age and sex of each of the children of the family. If the children came from parents one or both of whom were married more than once the exact relation of the various individuals was stated. Eye color was classed as blue, green, gray, hazel, brown and black, and hair color as yellow, light brown, dark brown, black, red and auburn. The printed forms were distributed mainly to the students of the University of Wisconsin with the request that so far as possible they fill them out in consultation with their parents during the holidays. Fairly complete data were received from 71 families including 406 individuals. While the data are not extensive nor free from sources of error they are, I think, sufficiently complete and reliable to enable one to draw several conclusions which have a high degree of probability.

Eye Color.

The color of the eyes is due to the factors causing blue, a dark brown granular melanin pigment, and in such cases a yellow pigment which is possibly a lipochrome. Blue is often darker in the young. "The darker shades of blue," according to Hurst, "are apparently due to the greater delicacy and transparency of the fibrous tissues of the iris through which the posterior pigment

is seen while the lighter shades of blue and the coarser grays seem to be due to the greater coarseness and opacity of the same tissues." These tissues "become coarser with age and young children with dark blue eyes may mature into adults with light blue, blue or gray eyes."

The various shades from light brown to black are due to different amounts of dark pigment deposited in the iris, blue eyes being those in which dark pigment is absent. Green is produced by a small amount of yellow pigment with blue or black. Yellow pigment, however, is of minor importance compared with the other color factors. Eyes commonly classed as gray may contain a small amount of dark pigment with the blue or blue and yellow or they may be due to a fine mottling of green and blue. Eyes are very commonly mottled in various ways, and they are frequently "ringed," the darker color being more dense around the margins of the pupil.

It is evident that eye colors cannot be divided into sharply defined classes. All sorts of intermediate shades occur as well as irregularities in the distribution of pigment over the surface of the iris. Color classes, therefore, are largely arbitrary categories. Perhaps, as the Davenports suggest, the most natural grouping is the one based on the presence or absence of melanin pigment. Black to light brown would fall into one class. Blue and green would fall into another while the grays would be divided between the two. There are, however, all grades in the amount of melanin pigment present and whether there are cases in which it does not exist in minute traces may reasonably be questioned. Hurst has divided eyes into the simplex and duplex types; in the former dark pigment occurs only in the posterior coat of the iris; in the latter in both coats. As a rule the darker colors belong to the duplex type, the lighter colors to the simplex type. This relation suggests that the difference may be due mainly to the amount of general pigmentation, the amount of pigment when small being deposited in the posterior coat and extending also into the anterior coat only when present in increased quantity. There is nothing which shows that these classes are not the result of a purely continuous series of variations.

Our results on the inheritance of blue eyes bear out in general

the conclusions of Hurst and the Davenports that blue behaves as a recessive to the pigmented condition. Blue × brown or black gives either brown or black, or brown or black with hazel, gray or blue which is the expected result if brown or black are heterozygotes. Blue × blue as a rule gives only blue. However the rule is not without exceptions. In one case a man with brown eyes was born of blue-eyed parents. Another instance was communicated by a gentleman who stated that both his parents had light blue eyes. Of their seven children all had blue eyes except one sister whose eyes were described as brown or dark hazel. Pearson gives one instance in which one member of a family of six children born of blue-eyed parents had dark brown eyes like those of the father's maternal grandfather.

In gray × blue matings, gray and blue were the usual result but brown eyes appeared in seven out of 72 offspring. In gray × gray matings brown eyes appeared once out of 17 offspring. Black eyes resulted in a few instances from brown × gray and brown × blue matings, but these cases may have been due to errors of classification, as brown eyes, especially if dark, are frequently described as black. Matings in which both parents have black or brown eyes may give either dark-eyed or light-eyed children. Thus black × black gave offspring with black, brown, gray and blue eyes. Matings in which one parent had dark eyes and the other light gave both dark-eyed and light-eyed offspring, but the proportion of the latter was considerably greater than in the previous case. In general we may say that the more darkly pigmented condition is dominant over the lighter, black over brown, brown over gray or blue, and gray over blue.

The inheritance of eye color in man, as is well known, is to a considerable degree alternative. How far it is Mendelian is a question rather difficult to answer on account of the intergradation of colors, limited knowledge of the ancestry of the families, and other causes. In man it is difficult to distinguish the pure dominants from the dominant-recessives; in fact it is impossible to do so with data covering only three generations. While it is probable that the blues are recessives there is no certainty in regard to the browns and blacks. Were blue-gray bearing

gametes present in equal numbers with the carriers of the darker colors we should expect to find light eyes in one fourth of the population. In a population in which over half the individuals fall into the light-eyed class it is evident that a much greater proportion than two thirds of the dark-eyed class are heterozygotes. In the 395 offspring tabulated the color of eyes was as follows: black 29, brown 110, hazel 3, gray 93, green 10, blue 150. It is safe to assume that much over three fourths of the dark-eyed individuals are heterozygotes but it is impossible to make more than a rough estimate of the ratio from the data at hand. In crosses of brown × blue we should expect half the offspring to be brown even if all the browns were heterozygous. If some of the browns were dominant the proportion would be greater. As a matter of fact we get 48 blacks or browns to 69 of the gray-blue class which is very different from the expected Mendelian ratio.

In crosses of brown × gray we get 30 of the dark class to 17 of the light which is more in accordance with the Mendelian expectation. In the black × blue crosses we get 30 of the dark color to 18 of the light which is very close to the preceding result. Black × gray gave 13 dark to 8 light.

Much of the data obtained may be interpreted as illustrating Mendelian inheritance but it is by no means certain that it should be so interpreted. There are, on the contrary, several cases which refuse to come under the Mendelian formula. There are indications that the inheritance is to a certain extent of the blended type. Crosses of brown or black with gray give a relatively greater number of browns than do crosses of brown or black with blue. Since gray frequently contains a certain amount of melanin pigment it is readily understood, if the inheritance is partially blended, why many more offspring should be raised into the brown category than in the crosses with blue. Again, compare the crosses of black × blue with those of brown × blue. In the former the proportion of blues is small, 4 out of 48, where the Mendelian expectation (if the blacks are predominantly heterozygous) is much greater. In the latter 46 out of 117 are blues. This can hardly be accounted for by any difference in the proportion of heterozygotes between the blacks and browns, which is

within the limits of probability. If the inheritance is partially blended we should expect that with increased pigmentation of either of the parents there would be an increased number of darkly pigmented children; and this we find. Inspection of Table I. will show many other cases which may be quite as readily interpreted as cases of blended inheritance as of mendelizing.

The principle of the non-transgressibility of the upper limit which is laid down by the Davenports represents only a very general tendency rather than a general law. Aside from the exceptions described Pearson records a family in which the two parents had light gray eyes, four children had eyes like their parents, while five others had black or brown eyes. De Candolle found that out of 257 individuals born of parents both of whom had gray or blue eyes 23 or 8.9 per cent. had brown eyes. I have met with one instance in which both eyes and hair were of a distinctly darker brown than they were in the darker parent. As we are not dealing with hard and fast unit characters but with different degrees of pigmentation it is not surprising that the eyes of children should occasionally be darker than those of the parents. This may account for some of the cases of apparent blends, but, in the light of our results on hair color, it is hardly probable that it can account for all.

Hair Color.

Hair color, like eye color, is the result of more than one factor. There is a granular dark brown melanin pigment which causes variations in intensity from light brown or yellow to black according to quantity. There is also a diffuse reddish pigment which may cause variations from reddish yellow to dark golden. These two kinds of pigment are usually mixed in various proportions; auburn and chestnut brown for instance arise from a combination of the two. Both these kinds of pigmentation appear to vary continuously and independently. The reddish pigment is frequently obscured by the brown. It may appear in children of parents with dark brown or black hair, but does not occur in children of light-haired parents who have no red pigment. Our data on the inheritance of red are meager, but so far as they go they confirm the conclusions of the Davenports on the inheritance of this color.

The effect of age upon the color of hair is so great that any conclusions based on the hair color of children as compared with their parents is of comparatively little value. The color of hair changes most rapidly in early life, but there is a considerable change even after sixteen years of age. We have made a rough estimate of the change by compiling the relative frequencies of the three most common colors in children under sixteen, in the members of the third generation in our data over sixteen, in the parents and in the grandparents. In children under sixteen black forms 9.8 per cent. of the individuals. In the members of the third generation over sixteen it forms approximately 20 per cent. In the parents and grandparents it forms in each case 39.2 per cent. Brown is less frequent under sixteen. It is most common in the children over sixteen, but in the parents and grandparents it is less common on account of so many developing into black. The light browns steadily decrease in number

TABLE SHOWING THE RELATIVE FREQUENCIES OF THE THREE MOST COMMON VARIETIES OF HAIR COLOR AT DIFFERENT AGES:

	Children under 16.	Children over 16.	Parents.	Grandparents.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Black	5 = 10	45 = 20	49 = 39.2	84 = 39.2
Brown	23 = 45.1	127 = 56.4	62 = 49.6	99 = 46.8
Light brown	23 = 45.1	53 = 23.5	14 = 11.2	31 = 14

SIMILAR TABLE COMPILED FROM THE DATA OF THE DAVENPORTS.

	Children.	Parents.	Grandparents.
	Per Cent.	Per Cent.	Per Cent.
Black	70 = 12.2	121 = 38.9	213 = 39.2
Brown	292 = 50	131 = 42.1	230 = 44.2
Light brown	212 = 36.9	59 = 18.9	99 = 18

with age. We have made a similar tabulation from the data given by the Davenports, although, since the ages of the children were not given, all of the third generation are treated together. In order to make the results more nearly comparable the browns and dark browns of the Davenports are classed as browns, and the light browns and yellowish browns as light browns. Their data show that black is over three times as prevalent in the parents as in the children while light brown is over twice as common in the children as in the parents or grandparents. The proportions of yellow, tow and flaxen are relatively greater in the

young as compared with the adults than light brown, tow occurring in twenty children and in none of the adults. The data agree with ours in showing little change between the parents and grandparents. It is evident that an investigation of the heredity of hair color under the assumption that the juvenile condition represents even an approximate record of heredity would be much like a study of the inheritance of stature from measurements of the height of school children.

Any conformability of the results thus obtained with Mendelian expectations, so far as ratios are concerned, means little. In fact if the ratios were approximately Mendelian before the effects of age were excluded they could not be Mendelian after the elimination of this factor.

TABLE I.

SHOWING THE NUMBER OF CASES OF THE VARIOUS KINDS OF EYE COLOR RESULTING FROM DIFFERENT MATINGS; BL, BLUE; BLK, BLACK; BR, BROWN; GN, GREEN; GY, GRAY; HZ, HAZEL.

Eye Color of Parents.	blk	br	gn	gy	bl	hz	Total.
blk × blk							
blk × br	4	8		1	4		17
blk × gn							
blk × gy	3	10		8			21
blk × bl	15	13		14	4	2	48
br × br		22			1		23
br × gn	1	3	1		1		6
br × gy	3	30	2	12	3	1	51
br × bl	3	45	6	17	46		117
gn × gn							
gn × gy							
gn × bl			1				1
gy × gy		1		11	5		17
gy × bl		7		28	37		72
bl × bl		1		2	49		52
Total.	29	110	10	93	150	3	395

The data obtained (see Tables II. and III.) warrant us in concluding that in the inheritance of colors depending on the granular dark brown pigment the same general tendencies prevail as in the inheritance of eye color. Dark hair tends to be dominant over the lighter colors. If both parents have dark hair the children will be predominantly dark haired but a certain number of light-haired children may appear. If one parent is dark haired and the other light haired both dark-haired and light-haired chil-

dren may be produced, but the latter will be more abundant than in the previous case. Light-haired parents rarely produce dark-haired children.

In order to eliminate so far as possible the effects of age a separate tabulation (Table III.) was made of the relation of the hair color of parents and grandparents. As we have seen, barring the effects of turning gray, there is comparatively little average difference between these two classes. In order to secure as much data as possible we have combined the uncompiled data of the Davenports in relation to parents and grandparents with our own. As this material was classified somewhat differently from ours

TABLE II.

SHOWING THE NUMBER OF CASES OF THE VARIOUS KINDS OF HAIR COLOR RESULTING FROM DIFFERENT MATINGS; AU, AUBURN; BLK, BLACK; BR, BROWN; LT BR, LIGHT BROWN; RD, RED; YL, YELLOW.

Hair Color of Parents.	blk	br	lt br	yl	au	rd	Total.
blk × blk	36	12	5		1	1	55
blk × br	38	49	27	1	9	3	127
blk × lt br	6	21	10	1	3		41
blk × yl	1		1	1			3
blk × au	4	12	4	1	6		27
blk × rd	1	2			3		6
br × br	4	66	17		3		90
br × lt br		8	16	2	4	1	31
br × yl		1					1
br × au	1	5	6	1	1		14
br × rd		1					1
lt br × lt br		2	4				6
lt br × yl							
lt br × au		1	1		1		3
au × au					1		
Total.	91	180	91	7	32	5	406

we have attempted to bring it so far as possible within the same categories; the browns and dark browns of the Davenports we have called browns, the yellow and golden colors have been grouped as yellow, the yellowish browns and light browns as light browns, the dark reds and auburns as auburns, and the blond and flaxen types as flaxen. The number of cases which might be classified differently from the grouping employed is quite small and could not vitiate any conclusions we have attempted to draw from the data.

It may be seen that in crosses of black and black that many cases of lighter hair make their appearance, a result that might be explained on the assumption that a considerable proportion of the blacks are heterozygous. In the crosses of black and brown we should naturally expect to get a larger percentage of browns and lighter colors, and this we find. In the crosses of black with light brown the proportion of browns and lighter colors is very different from the Mendelian expectation in the light of the preceding results. If all the blacks were heterozygous, the blacks should constitute 50 per cent. of the product instead of much less than a third; while, since some of the blacks may be safely assumed to be homozygous, the black-haired offspring should

TABLE III.

SHOWING THE INHERITANCE OF HAIR COLOR OF PARENTS FROM GRANDPARENTS.

Hair Color of Grandparents.	blk	br	lt br	yl	au	rd	flxn	Total.
blk × blk	49	18	5		1	2		75
blk × br	46	34	6		3			89
blk × lt br	10	17	7		1		1	36
blk × yl			1					1
blk × au	4	2		1	2			9
blk × rd	6	2			2	2		12
blk × flxn		2					2	4
br × br	10	55	14	2		3	1	85
br × lt br	8	18	21		2	2		51
br × yl	2		1					3
br × rd	3	5	1			1		10
br × flxn		2	2					4
lt br × lt br	1	3	11					15
au × au					1			1
flxn × flxn				1			6	7

exceed 50 per cent. Crosses of browns with browns give a larger number of browns than result from crosses of browns and light browns; but it is noteworthy that a considerable proportion of black-haired individuals result from both these unions.

While the data indicate that the inheritance of hair color in man is, to a certain extent, alternative, it certainly does not justify us in concluding that it is Mendelian. That it is to a certain extent of the blended type is indicated by the fact that crosses of black with light brown yield a much less proportion of blacks and a greater proportion of browns than do crosses of blacks with brown. If black were a typical Mendelian dominant it should occur in

equal proportions in both cases. In fact many of the results obtained by the Davenports and ourselves may be interpreted quite as readily as blended inheritance as anything else.

It is a rule laid down by the Davenports that "in the midst of varying degrees of melanic pigmentation the intensity of melanic pigmentation never exceeds that of the more intense parent." This is a general rule borne out also by our data; but it is by no means universal. While the data compiled by the Davenports show few or no cases in which this rule is plainly violated, I find upon examining their data on the relation of parents and grandparents, a considerable number of exceptions. Apparently no account of these relations was taken, the data concerning the grandparents being used only on account of the light it might throw on the probable constitution of the gametes. In one respect these data are more valuable than what was used, which

TABLE IV.

SHOWING INHERITANCE OF THE CORRELATIONS OF EYE COLOR AND HAIR COLOR.

Combination.		No. Families in which Occurs.	Inheritance as Correlated Variation.	Appeared in Generation I. or II. but not Transmitted as Correlated Variation.	Appeared in Generation III. only.
Hair.	Eye.				
blk	blk	23	13	12	
blk	br	28	37	10	
blk	bl	17	8	11	
blk	gy	14	5	9	
br	br	23	40	5	
br	bl	37	55	9	2
br	gy	24	22	12	
lt br	bl	27	18	7	14
rd	bl	4	3	2	1
au	bl	8	13	2	1
au	br	6	0	3	4
lt br	gy	19	6	5	15

was derived from the members of the third generation, as the effects of immaturity are mainly eliminated. In their table 7a, the rule is violated in 5 out of 13 families, black hair in the father of the Sim family coming from parents both of whom had light brown hair. In the other tables given, less frequent deviations are found but they are sufficient to justify a doubt that the non-transgressibility of the upper limit represents anything other than a more or less predominant tendency. In Table III. it may

TABLE V.

Reference No.	Generation I.				Generation II.		Generation III.	
	Father's Father.	Father's Mother.	Mother's Father.	Mother's Mother.	Father.	Mother.	Hair.	Eye.
1 hair.	rd	blk	lt br	blk	blk	br	1 dk br	dk br
eye.	bl	blk	gy	bl	dk br	bl	3 rd	bl
							3 br	bl
							1 blk	blk
2 hair.	blk	blk	b	br	blk	br	4 br	bl
eye.	gy bl	br	bl	bl	br	bl	1 br	br
3 hair.	lt br	blk	lt br	blk	dk br	dk br	4 lt br	bl
eye.	br	bl	gy	br	bl	gy	5 dk br	bl
							1 dk br	gy
4 hair.	lt br	blk	blk	blk	blk	br	4 br	br
eye.	bl	blk	gy	br	gy	br	1 lt br	gn
5 hair.	—	br	—	blk	br	rd br	3 lt br	bl
eye.	bl	bl	bl	br	bl	bl	1 yl	bl
6 hair.	blk			br	blk	br	2 lt br	bl
eye.	bl	bl	bl	bl	bl gy	bl	2 dk br	bl gy
							1 dk br	bl
7 hair.	br	br	br	br	br	br	2 br	br
eye.	bl	br	br	bl	br	bl	2 br	bl
8 hair.	br	br	br	br	br	blk	1 br	bl
eye.	bl	br	blk	bl	br	blk		
9 hair.	br	br	br	blk	blk	blk	2 br	br
eye.	bl	bl	bl	blk	br	blk	2 blk	br
10 hair.	br	br	blk	br	br	br	1 br	bl
eye.	bl	br	blk	bl	br	gy	1 blk	blk
							1 lt br	bl
11 hair.	br	lt br	blk	lt br	blk	blk	1 dk br	blk
eye.	bl	bl	blk	bl	bl	blk	2 blk	br
							1 lt br	bl
							2 dk br	gy br
12 hair.	br	br	blk	br	br	br	2 br	bl
eye.	gy	bl	blk	bl	gy	gy	1 lt br	bl
13 hair.	—	—	lt br	lt br	br	lt br	3 lt br	bl
eye.	—	—	bl	bl	gy	bl	2 lt br	gy
							1 br	bl
14 hair.	blk	blk	au	blk	blk	blk	2 lt br	bl
eye.	bl	bl	bl	"gn br"	bl	gn br	2 blk	bl
15 hair.	blk	blk	br	blk	br	br	1 lt br	bl gy
eye.	bl	gy	bl	bl	bl	bl		
16 hair.	au	blk	blk	br	blk	blk	1 blk	br
eye.	gy bl	gy bl	br	bl	gy bl	br	1 au	br
							2 br	gy
							1 br	bl gy
17 hair.	yl	br	br	br	lt br	br	1 rd	bl
eye.	bl	br	bl	gy	bl	bl		

TABLE V.—*Continued.*

Reference No.	Generation I.				Generation II.		Generation III.	
	Father's Father.	Father's Mother.	Mother's Father.	Mother's Mother.	Father.	Mother.	Hair.	Eye.
18 hair.	br	blk	lt br	blk	au	br	2 br	br
eye.	—	—	bl	blk	gy	br	2 lt br	gy
							1 blk	br
							1 br	blk
19 hair.	—	au	—	—	br	—	3 au	bl
eye.	blk	bl	bl	br	br	blk	2 blk	blk
20 hair.	—	—	—	au	br	br	1 br	br
eye.	bl	—	blk	bl	bl	br	1 lt br	bl
							3 au	bl
21 hair.	au	blk	blk	au	au	blk	2 au	bl
eye.	bl	blk	blk	bl	bl	blk	1 br	hz
22 hair.	blk	br	au	au	blk	au	3 br	br
eye.	blk	br	bl	bl	blk	bl	1 yl	blk
							1 blk	blk
							1 br	hz
23 hair.	"reddish"	br	—	—	"reddish"	blk	3 br	br
eye.	hz?	hz	blk	—	bl	br	2 au	bl
24 hair.	blk	blk	dk br	blk	blk	blk	4 blk	gn
eye.	bl	bl	bl	br	bl	br	1 blk	br
25 hair.	dk br	"blond"	blk	br	br	blk	2 blk	br
eye.	br	bl	br	br	br	br	1 lt br	bl
							1 br	br
							2 lt br	br
26 hair.	blk	lt br	blk	blk	br	br	3 br	br
eye.	br	bl	br	bl	gn	br	1 lt br	gn
							1 lt br	blk
							1 lt br	bl
27 hair.	lt br	br	br	br	lt br	br	2 br	gy
eye.	bl	br	bl	gy	bl	gy	2 lt br	gy
28 hair.	lt br	br	lt br	lt br	br	lt br	1 au	br
eye.	bl	br	br	bl	br	bl	1 br	gy
							1 yl	bl
							1 br	br
29 hair.	br	lt br	lt br	blk	lt br	cht	1 cht	bl gy
eye.	bl gy	bl gy	bl gy	blk	bl	blk	1 br	br
30 hair.	blk (?)	blk	br	br	blk	lt br	3 br	br
eye.	gy	br	bl	gy	br	gy bl	1 lt br	gn gy
31 hair.	blk	dk br	br	dk br	blk	dk br	4 br	br
eye.	blk	gy	gy bl	gy	blk	gy gn	1 blk	br
							2 lt br	lt br
							1 au	gy
32 hair.	blk	blk	blk	blk	blk	blk	8 blk	br
eye.	br	br	br	br	br	br		

TABLE V.—*Continued.*

Reference No.	Generation I.				Generation II.		Generation III.	
	Father's Father.	Father's Mother.	Mother's Father.	Mother's Mother.	Father.	Mother.	Hair.	Eye.
33 hair.	br	blk	lt br	br	blk	sandy (rd)	4 br	gy
eye.	bl	br	bl	bl	gy br	bl	1 br	bl
							2 lt br	bl
							1 yl	bl
							1 blk	br
							1 lt br	br
34 hair.	blk	blk	blk	blk	rd	blk	1 au	bl
eye.	bl	gy	bl	gy	br	bl	2 dk br	bl
							1 br with red streaks	br
35 hair.	—	—	br	br	br	br	4 br	gy
eye.	—	—	bl	bl	gy	bl	2 br	bl
							1 lt br	bl
							1 lt br	gy
36 hair.	—	—	br	br	br	br	2 br	bl
eye.	—	—	gy	bl	br	bl		
37 hair.	—	lt br	—	—	reddish yl	blk	1 blk	gy
eye.	—	gy	—	—	bl	gy	1 yl	bl
							1 lt br	bl
38 hair.	blk	br	lt br	br	blk	br	1 br	br
eye.	blk	bl	bl	bl	br	bl	1 br	bl
39 hair.	blk?	dk br?	br	—	blk	lt br	2 dk br	dk br
eye.	gy?	dk br	gy	—	dk br	gy	lt br	hz
							lt br	bl
40 hair.	dk br	blk	br	br	blk	br	2 br	gy
eye.	bl	br	bl	br	gy	br	3 br	br
							2 blk	br
							1 lt br	gy gn
41 hair.	lt br	br	blk	blk	dk br	blk	2 blk	br
eye.	bl	bl	br	br	bl	br	1 blk	gy
							1 lt br	gy
							1 lt br	bl
42 hair.	br	br	—	—	br	blk	4 lt br	bl
eye.	bl	bl	—	—	bl	bl		
43 hair.	br	br	blk	blk	br	blk	4 br	gy
eye.	bl	bl	br	blk	bl	blk	1 blk	blk
							1 blk	gy
							1 lt br	gy
44 hair.	—	—	rd	br	br	br	1 br	gy
eye.	—	—	bl	gy	gy	bl		
45 hair.	blk	blk	—	blk	br	br	2 br	bl
eye.	bl	bl	—	br	bl	bl	3 lt br	bl
46 hair.	rd	blk	blk	blk	au	blk	2 lt br	bl
eye.	bl	bl	bl	blk	bl	br	1 dk br	bl

TABLE V.—*Continued.*

Reference No.	Generation I.				Generation II.		Generation III.	
	Father's Father.	Father's Mother.	Mother's Father.	Mother's Mother.	Father.	Mother.	Hair.	Eye.
47 hair.	dk br	lt br	very lt br	blk	br	blk	1 gldn	br
eye.	br	bl	bl	bl	br	gy	1 dk br	gy
							1 blk	blk
							1 blk	br
							1 lt br	gy
48 hair.	blk	br	blk	br	blk	au	2 br	gy
eye.	bl	gy	gy	bl	bl	br	1 br	bl
							1 lt br	br
49 hair.	lt br	blk	blk	blk	br	blk	1 br	br
eye.	gy	blk	bl	blk	gy	blk		
50 hair.	blk	blk	blk	blk	blk	dk br	1 lt br	gy
eye.	bl	gy	gy	gy	gy	br	1 au	br
51 hair.	lt br	lt br	blk	dk br	br	blk	5 lt br	gy
eye.	gy	gy	gy	br	bl	br	4 br	br
							1 blk	br
52 hair.	br	blk	lt br	au	br	lt br	1 au	gy
eye.	gy	br	bl	gy	br	bl	2 au	br
							1 br	br
							1 lt br	gy
							1 yl	blk
53 hair.	au	br	br?	dk br	br	br	1 br.	gy
eye.	br	bl	bl	blk	bl	gy	1 dk br	gy gn
54 hair.	blk	blk	blk	blk	blk	dk br	1 blk	br
eye.	blk	br	bl	bl	br	gn bl	1 dk br	bl
							1 lt br	gy bl
55 hair.	br	blk	br	br	blk	br	1 dk br	br
eye.	gy	blk	bl	bl	blk	bl	1 lt br	bl
56 hair.	br	lt br	br	blk	lt br	lt br	14 br	hz
eye.	br	lt br(hz?)	br	blk	lt br (hz)	gy	1 br	gy
57 hair.	br	br	br	dk br	br	br	2 br	br
eye.	bl	bl	gy	br	bl	br	1 dk br	br
							1 br	bl
							1 br	gy br
58 hair.	dk br	dk br	dk br	dk br	dk br	blk	1 blk	bl gy
eye.	gy	gy	gy	gy	gy	bl gy	1 br	bl gy
59 hair.	blk	au	dk br	lt br	lt br	lt br	1 lt br	blk
eye.	blk	br	bl	br	br	bl	1 lt br	br
60 hair.	lt br?	dk br	dk br	blk	lt br	blk	1 blk	br
eye.	bl	gy	br	blk	bl	br	2 lt br	bl
							1 dk br	br
61 hair.	blk	dk br	blk	br	blk	au	1 au	br
eye.	blk	gy	br	bl	br	br		
62 hair.	—	blk	br	—	dk br	br	2 br	br
eye.	—	blk	br?	—	br	br		
63 hair.	br	br	br	br	br	br	3 br	bl
eye.	bl	bl	bl	bl	bl	bl		

TABLE V.—*Continued.*

Reference No.	Generation I.				Generation II.		Generation III.	
	Father's Father.	Father's Mother.	Mother's Father.	Mother's Mother.	Father.	Mother.	Hair.	Eye.
64 hair.	br	lt br	br	—	lt br	blk	1 blk	gy
eye.	gy	bl	—	—	bl	br		
65 hair.	br	blk	lt br	blk	blk	br	2 br	br
eye.	gy	br	bl	br	br	br		
66 hair.	blk	br	br	br	blk	br	1 dk br	bl
eye.	—	—	bl	gy	gy	gy	2 dk br	gy
							4 dk br	br
							1 lt br	br
67 hair.	—	—	—	blk	blk	blk	2 lt br	bl
eye.	—	—	—	bl	br	bl	1 blk	br
68 hair.	—	—	—	—	br	br	3 br	bl
eye.	—	—	-	—	bl	bl		
69 hair.	—	—	blk	br	blk	dk br	2 dk br	bl
eye.	bl?	bl?	bl?	gy	bl	br		
70 hair.	—	—	—	—	—	—	3 blk	bl
eye.	—	—	—	—	gy	bl	1 br	gy
							1 dk br	bl
71 hair.	—	blk	—	blk	blk	blk	1 blk	gy
eye.	—	br	—	blk	gy	br	1 blk	blk

be seen that black appears in 10 out of 85 cases in crosses of brown and brown ; in 8 out of 51 cases in crosses of brown and light brown, as well as in a few cases of crosses of brown with red and yellow. A few cases have come under my personal observation in which the hair of one of the offspring was distinctly darker than that of the darker parent.

It is well known that there is a certain correlation between the colors of hair and eyes, such as the association between dark hair with dark eyes, and light hair with light eyes. Table IV. shows that black hair may be associated with black eyes or with eyes containing less pigment, the combination of black and blue being not uncommon. Brown hair may be associated with brown eyes or the lighter shades, but not with black eyes. Light brown hair is associated with gray eyes or blue eyes but not with the darker colors. Auburn hair may occur with brown eyes, but red hair, which contains less melanin pigment, usually is associated with blue eyes. Probably fuller data would furnish exceptions to the above rules. According to our results dark hair

may be associated with light color of eyes but light hair is not associated with dark color of eyes. Light-haired individuals, if adults, are pretty sure to have eyes of the blue or gray type, with little melanin pigment.

The data in Table IV. show that the inheritance of the correlation of hair color and eye color is not very strong. In the first column is given the number of matings in which certain combinations occur; in the second, the number of cases among these matings in which the combination appears in the offspring; in the third, the number of cases in which the combination occurred in which it failed to be transmitted. Black eyes and black hair both behave as dominant characters, but it frequently happens that parents, one of whom has black eyes and black hair, will produce a child with black hair and blue eyes, although they will not produce one with black eyes and light hair. We cannot be dealing here with two independently mendelizing characters, because the independence is purely a one-sided one.

Summary.

1. In the inheritance of the color of hair and eyes, the more pigmented condition tends to be dominant over the less pigmented.

2. Crosses of more darkly pigmented types produce a number of dark types as well as a number of lighter ones, but crosses of the lighter types rarely produce darker ones.

3. Inheritance of eye color and hair color, although partly alternative, conforms to a certain extent to the blended type.

4. There is a certain amount of evidence that the pigmentation of eyes and hair may exceed that of both parents, especially when both parents are pigmented to the same degree.

5. Dark hair may be associated either with dark eyes or light eyes, but light hair does not occur along with darker eyes.

6. Correlations of hair color and eye color are not strongly inherited.